QUARK INTERCHANGE EFFECTS IN THE KN INTERACTION

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We study the short range repulsion in the KN system due to quark-gluon exchange. Phase shifts for spin-spin, color Coloumb and spin-orbit interactions are presented.

It has been argued [1] that a more suitable investigation of the short range part of the hadronic repulsion could be made in the KN system. In the constituent quark model the $K^+ = u\,\bar{s}$ and $K^- = s\,\bar{u}$ while the nucleon is a *uud* or *ddu* state so, in the non-relativistic limit, simple quark exchange mechanism can be applied to the K^+N system. Many groups have studied this system in the S-wave [2]. An extension in order to include higher partial waves, such as the P-waves, is the subject of our research.

The method we employ in order to introduce the quark-gluon degrees of freedom is known as the Fock-Tani formalism [3]. The central idea in the Fock-Tani method is the change of representation concept. The operators of the composite particles are redescribed by ideal operators which obey canonical (anti)commutation relations. These ideal operators act on an enlarged Fock space which is a graded direct product of the original Fock space and an "ideal state space" [3]. The ideal operators correspond to particles with the same quantum numbers as the composite ones of the system. A change of representation is implemented by means of a unitary transformation, which transforms the single-composite states into single-ideal states. When the unitary transformation is applied to the microscopic quark-quark Hamiltonian one obtains the effective interaction. The meson-baryon potential can be obtained applying in a standard way the Fock-Tani transformed operators to the microscopic Hamiltonian [4]:

$$V_{\mathrm{meson-baryon}} = \sum_{i=1}^{4} V_i(\alpha\beta;\delta\gamma)\, m_\alpha^\dagger\, b_\beta^\dagger\, m_\gamma\, b_\delta \qquad (1)$$

and

$$\begin{aligned}
V_1(\alpha\beta;\delta\gamma) &= -3V_{qq}(\mu\nu;\sigma\rho)\,\Phi_\alpha^{*\mu\nu_2}\,\Psi_\beta^{*\nu\mu_2\mu_3}\,\Phi_\gamma^{\rho\nu_2}\,\Psi_\delta^{\sigma\mu_2\mu_3}\\
V_2(\alpha\beta;\delta\gamma) &= -3V_{q\overline{q}}(\mu\nu;\sigma\rho)\,\Phi_\alpha^{*\mu_1\nu}\,\Psi_\beta^{*\mu\mu_2\mu_3}\,\Phi_\gamma^{\sigma\rho}\,\Psi_\delta^{\mu_1\mu_2\mu_3}\\
V_3(\alpha\beta;\delta\gamma) &= -3V_{qq}(\mu\nu;\sigma\rho)\,\Phi_\alpha^{*\mu\nu_2}\,\Psi_\beta^{*\mu_1\nu\mu_3}\,\Phi_\gamma^{\mu_1\nu_2}\,\Psi_\delta^{\sigma\rho\mu_3}\\
V_4(\alpha\beta;\delta\gamma) &= -6V_{q\overline{q}}(\mu\nu;\sigma\rho)\,\Phi_\alpha^{*\nu_1\nu}\,\Psi_\beta^{*\mu_1\mu\mu_3}\,\Phi_\gamma^{\mu_1\rho}\,\Psi_\delta^{\nu_1\sigma\mu_3}.
\end{aligned}$$

The general potential (1) can be specialized to study the KN system [5]. Details of this calculation, for the higher partial waves, will be shown elsewhere [6]. In the present calculation for the S and P waves we will use the microscopic quark-quark potential and quark-antiquark potential written as

$$\begin{aligned}
V_{qq\ \mathrm{or}\ q\overline{q}}^{\mathrm{OGEP}} = 4\pi\alpha_s \Bigg[\frac{1}{q^2} - \frac{2}{3m_1m_2}\mathbf{S}_i\cdot\mathbf{S}_j + \frac{i}{q^2}\Bigg\{ \frac{\mathbf{S}_1\cdot(\mathbf{q}\times\mathbf{p}_1)}{2m_1^2} - \frac{\mathbf{S}_1\cdot(\mathbf{q}\times\mathbf{p}_2)}{m_1m_2}\\
-\frac{\mathbf{S}_2\cdot(\mathbf{q}\times\mathbf{p}_2)}{2m_1^2} + \frac{\mathbf{S}_2\cdot(\mathbf{q}\times\mathbf{p}_1)}{m_1m_2}\Bigg\}\Bigg]
\end{aligned}$$

The first term is the color Coulomb interaction, the second term is the spin-spin interaction and last one is the spin-orbit interaction. A scattering amplitude can be obtained from the Fock-Tani formalism such that the KN OGEP (One-Gluon Exchange Potential) can give rise, in the Born approximation, to an amplitude h_{fi}^{KN} presented in ref. [7]. The phase shifts can be calculated by

$$\delta_l^{\mathrm{KN}} = -\frac{2\pi^2 P_{cm}E_K\,E_N}{E_K+E_N}\int_{-1}^{1} d\mu\; h_{fi}^{\mathrm{KN}} P_l(\mu)$$

where $P_l(\mu)$ is the Legendre polynomial of order l and $E_i = \sqrt{P_{cm}^2 + m_i^2}$.

In Figs. 1 and 2 phase shifts are presented for the following partial waves: S_{01}, S_{11}, P_{01}, P_{11}, P_{03}, P_{13} (where the notation $L_{I,2J}$ is used).

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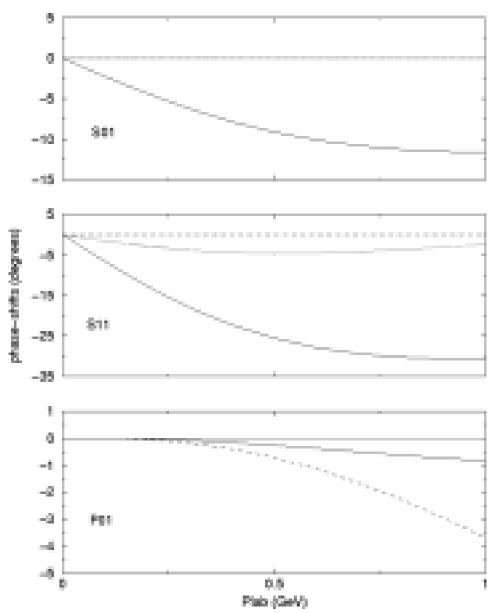

Figure 1. KN phase-shifts: spin-spin solid line, Coulomb dotted line, spin-orbit dashed line.

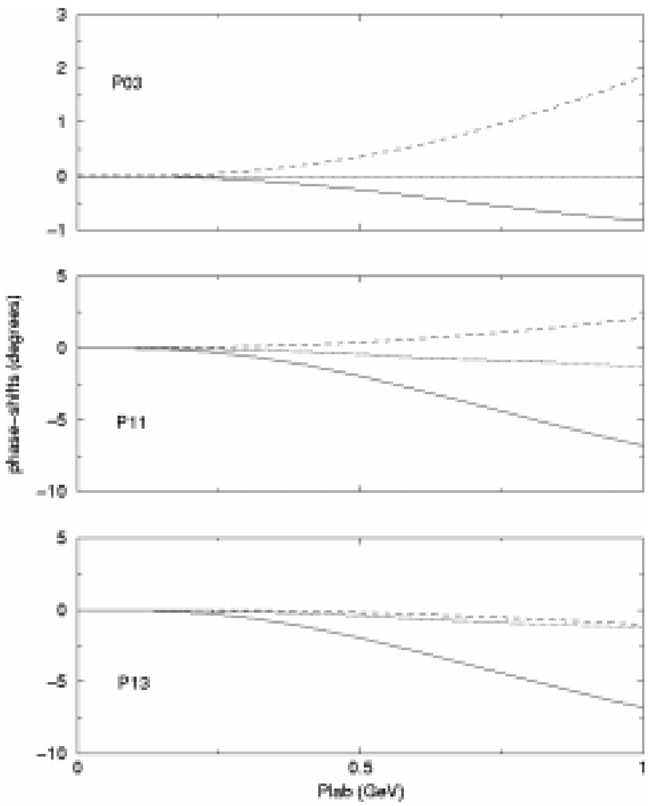

Figure 2. KN phase-shifts: spin-spin solid line, Coulomb dotted line, spin-orbit dashed line.